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Innovative Applications of O.R.

Restructuring the resident training system for improving the equity of access to primary care

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ABSTRACT

Many countries experience maldistribution of health professionals, represented by a mismatch between the spatial distribution of inhabitants and that of the providers. Various policies are employed by the governments to attract workforce to underserved communities. For example in Canada, such policy initiatives as alternative models of care for rural areas, promotion of rural medicine programs and financial incentives and many more were used to try and improve the situation. Despite these efforts, the disparity continues. Empirical evidence suggests that the most pertinent factor affecting health professionals' choice to practice in underserved and rural communities is their background. In particular, research shows that trainees of rural background are much more likely to practice in rural areas, once training is finished. The proposed MIP optimization model concentrates on education as a means to improve the spatial distribution of professionals. It incorporates interests of two main stakeholders, namely the regulator (in the objective function) and the health professionals (directly incorporating the choice patterns of the graduates), and provides the optimal training locations and required backgrounds of trainees in each location. A realistic case for designing the postgraduate family-medicine education program of Ontario is provided. We have demonstrated that depending on the choice patterns of the trainees, an improved distribution of professionals can be achieved by better positioning locations of residency training. More importantly, we demonstrate that in some cases, expanding the programs and training a larger number of trainees without taking their backgrounds into consideration can worsen the future inequity.

1. Introduction

Policy makers worldwide are concerned with providing populations with accessible and effective health services. One of the main contributors to effectiveness and availability of healthcare is the number of available health professionals. World Health Organization (2006) report finds that the public health suffers when there are not enough health workers (see also Anand and Bärnighausen, 2004; Sousa, Tandon, Prasad, Dal Poz, & Evans, 2006). Despite the recognized importance of sufficient health workforce, in many countries there are vast areas that suffer from a scarcity of professionals. A 2010 report from the World Health Organization estimates that around 50% of the world's population reside in rural and remote areas, and at the same time only 24% of the physicians are practicing there. A similar problem is observed in Canada. The Canadian Institute for Health Information (2014) report points out that 18% of the population live in rural areas and 14.4% of family medicine physicians and 2% of specialists are located in these regions (this accounts for 8.5% of all physicians). Kralj (2001) and Tepper, Schultz, Rothwell, and Chan (2005) discuss the extent of the problem for Ontario, the most populated Canadian province. These papers consider not only the overall number of professionals in specific areas (rural versus urban), but also the spatial distribution of the professionals. The disparity they present is between the spatial distribution of health providers and that of the population (denoted "maldistribution" by the Canadian Institute for Health Information, 2005).

In the literature, rural rearing has been consistently found as the common and most significant factor that influences the recruitment and retention of rural physicians. The WHO (2010) report states that there is a compelling body of evidence from high-, middle- and low-income countries that a rural background increases the chance of graduates returning to practice in rural communities. A Cochrane systematic review by Grobler et al. (2009), emphasizes: "[Rural background] appears to be the single factor most strongly associated with rural practice". For Canada,

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Woloschuk and Tarrant (2004), Rourke, Incitti, Rourke, and Kennard (2005), Rourke (2008), Mathews, Seguin, Chowdhury, and Card (2012) and others confirm these findings.

Motivated by the above, this paper focuses on the education system as a means to improve the equity in the spatial distribution of general practitioners (GPs, sometimes also called primary care or family physicians), and hence their overall accessibility. Although education has been identified as a potential policy tool by the WHO and many other researchers, to the best of our knowledge there is no analytical work to demonstrate its potential impact. We aim at answering the following question: *Is it possible to improve the spatial distribution of general practitioners by optimizing the residency training locations and the (rural versus urban) background of the admitted residents?* Adopting a regulator's perspective, we develop a mathematical formulation that determines the number of residents of a certain background to be trained at each residency location, so as to minimize an inequity measure pertaining to the locations they are likely to choose.

Although the inequity in the distribution of providers has been discussed intensely by the health policy literature, our contribution is to tackle this problem from the operations research perspective. The proposed model can be used to improve spatial distribution of any maldistributed provider. This paper focuses on primary care providers, namely general practitioners. Despite the fact that primary care is widely recognized as affecting the overall health of populations and many countries are interested in delivering it in an efficient, effective and timely fashion, the relevant operations research literature in the area is rather sparse. Also, prevailing studies assume that it will be possible to recruit sufficient numbers of GPs to operate the facilities in the recommended locations (see for example Graber-Naidich, Carter, & Verter, 2014). This assumption is unrealistic, as practitioners choose their practice locations according to their personal considerations. The model presented here tackles this problem and provides a more realistic perspective on the delivery of primary care.

Professionals' preferences are modeled explicitly, using as a basis the spatial interaction model by Huff (1962), and considering factors that influence choice. To the best of our knowledge, explicit modeling of the professionals' choices is novel in this context. The only paper that combined the preferences of primary care professionals with OR modeling is by Güneş, Yaman, Çekyay, and Verter (2014). In this paper, preferences were indirectly represented using lower and upper bounds on assigned panel sizes as a measure of income, professional support, workload and equity of income, in contrast to our explicit modeling.

The paper is organized as follows. Section 2 provides a literature review. We present the mathematical formulation in Section 3. Next, results for a realistic case based on Ontario, Canada are presented. We finish with a discussion and concluding remarks.

2. Literature review

Two streams of literature are particularly relevant to our work: (i) measures of equitable distribution of resources and the appropriate choice of measure in the context of health professionals; (ii) modeling user choice in general and health professionals' choice in particular. In the remainder of this section an overview of the most pertinent works in these two areas is provided, in an effort to better position the paper and highlight its contributions.

Equity of distribution is an important measure when considering location and distribution decisions of public services (schools, libraries, health services etc.). Past researchers agree that the equity measure should be selected in accordance with the problem at hand, as many possible metrics exist and there is no universally appropriate one. A review of twenty different equity metrics is provided in Marsh and Schilling (1994). Another review is provided in Eiselt and Laporte (1995). Marsh and Schilling present seven desirable criteria to help researchers choose the most appropriate equity measure for their specific goal (among these analytic tractability, appropriateness, principle of transfers and others). Equity measures used in the past for healthcare and location problems include variance of travel distances (Drezner & Drezner, 2007), range of travel distances (Drezner, Thisse, & Wesolowsky, 1986; Mitropoulos, Mitropoulos, Giannikos, & Sissouras, 2006), sum of weighted deviations from a service standard (Smith, Harper, & Potts, 2013), the Gini coefficient for distances of travel (Drezner, Drezner, & Guyse, 2009; Maimon, 1986), minimization of the total travel time – minisum objective (Mestre, Oliveira, & Barbosa-Póvoa, 2012), minimizing differences of utilization from a national norm (Oliveira & Bevan, 2006), the Quintile Share Ratio (Drezner, Drezner, & Hulliger, 2014) and others.

In our context, the maldistribution of health professionals is measured often times by applying the Gini coefficient to the physician-to-population ratios. Studies using the coefficient to demonstrate the disparities in distribution of professionals were conducted in numerous countries. For the US (McConnel & Tobias, 1986) used data from the American Medical Association's Physician Masterfiles for 1963–1980 and the Gini index and show that a more uniform distribution of physicians happened in all major categories of physicians except General Practitioners. Politzer, Cultice, and Meltzer (1998) applied Gini to assess the geographic distribution of physicians in the USA and the contribution of International Medical Graduates (IMGs) to improving or exacerbating this distribution. They found that physician growth has not produced improvements in the geographic distributions and that the IMGs generally made the situation even worse.

For Canada, Kralj (2001) applied the GINI index to gauge the maldistribution of physician resources in Ontario during the 1990s. The results revealed that despite numerous government policies and programs aimed at alleviating the geographic maldistribution of medical human resources, the distribution of physicians in Ontario had become more uneven during the 1990s. Brown (1994) was evaluating the geographic distributions of health and social service practitioners in Alberta, Canada, relying on four Gini-style indices. He concluded that Albertan doctors were heavily concentrated in urban areas during 1987–1991. More importantly, he noted that "elimination of rural-urban differences in practitioner availabilities will not occur if the only policy is expansion of the total number of practitioners, while allowing manpower markets to remain spatially unfettered".

For Turkey, Çalişkan (2013) was using GINI to assess the distribution of physicians and determine the main factors behind their location decisions in Turkey. The calculations showed that both the overall and regional disparities have decreased dramatically between 1965–2007. In addition, the findings indicated that the population density is one of the main determinants of location choices. Other explanatory variables, such as hospital beds, were found to have a significant effect on the distribution of physicians supply.

The Gini coefficient is the most widely recognized equity measure in the economical and social welfare literature (Marsh & Schilling, 1994). In addition, it satisfies all the desirable criteria mentioned in Marsh and Schilling (except the pareto optimality principle), the most important of which is the principal of transfers (Mandell, 1991). Hence, it was chosen as the equity measure and the regulator's objective in this paper. Nonetheless, any other relevant equity measure of interest can be incorporated. Using the Gini coefficient for service-per-population ratios, Mandell (1991), proposes a model that balances equity and effectiveness. He provides a formula for Gini coefficient that is convenient mathematically and is based on perceived "envy" between different groups of population. We base our methodology on a similar formulation for the Gini coefficient.